Response to reviewers

Reviewer comments in black *- Answers in blue italic*

Line numbers referenced in this document correspond to the manuscript version with tracked changes.

Reviewer 2:

Thanks to the authors for their revised manuscript. I am mostly happy with the changes made, however, I do still think the model description could be clarified.

We thank the reviewer for the positive feedback. We have incorporated all the specific suggestions provided below to further clarify the model description.

I still can't quite tell how surface melt is a) calculated or b) included into the model.

For a: the authors say in their response it is "computed from the air temperature and degree-day model", with a citation to Gilbert et al 2022 - could you expand on this? Integrated temperature above 0 for the day? Maybe the modelled flux could be added to figure 2a to see how this compares to the measured discharge?

The surface melt rate is calculated at each simulation timestep (48 min) as proportional to temperature above 0°C during the timestep. The proportionality factor, known as the 'degree day' factor, is adjusted so that the integrated water flow in the model matches the total discharge measured at the cavitometer. We have now expanded the description of the melt model in the revised manuscript (L153-165) and added the modeled discharge to Figure 2a.

For b: I appreciate the clarification of how the sliding law is used in the full Stokes model, but I think the key step of how meltwater comes into the sliding law is still missing. Am I right that the sliding law used in this paper is equation (12) from Gilbert 2022? This comes from combining the steady state of equation (2) in the present manuscript with equation (1) and an unstated flow law (equation 11 of Gilbert22?) and then using fitted values of Qmax and an exponent. I think it would be more helpful to give equation (12) of Gilbert 2022 directly, rather than present the time-dependent model that is not used? I think it is also worth reminding the reader of the assumed turbulent flow law as this is where the link to surface melt is introduced. If I have misunderstood, I apologise, but I think this speaks to the lack of clarity here. In particular, the phrase "with surface meltwater and rainfall provided as source terms in the hydrological model to force the model" means nothing, because none of the equations listed include either of those as terms.

We apologize for the lack of clarity. Equation (12) from Gilbert et al. (2022) is not used here. The link between sliding and meltwater is established by solving the full subglacial hydrological model to obtain the effective pressure N used in equation (2). Specifically, meltwater is given as a source term m_input in the equation describing the hydraulic potential evolution. This equation is provided in the Supplementary Material of Gilbert et al. (2022) as Equation S2. Note that the Gilbert et al. (2022) model is largely based on the GlaDS model (Werder et al., 2013), in which only the sheet thickness evolution (and conductivity) has been modified to allow consistent coupling with the friction law. The hydraulic potential equation is the same as that given in Werder et al. (2013) (Equation 24) where the source term m is the surface melt in our study.

The surface melt is thus directly supplied per unit of area (m w.eq.) to the base of the glacier, as computed by the degree-day approach described above. This drives the evolution of hydraulic potential, from which the effective pressure N is calculated to determine theta (Equation 2). The value of theta provides the current basal friction necessary to solve the Stokes problem (Equation 1).

We have modified the manuscript to clarify how meltwater is used in the ice flow model (L153-165 and a new section 2.5 L168).